Muons in Search for Hidden Pyramid Chambers

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Earth is showered constantly by particles called muons that are created by cosmic rays, and clever scientists are finding ways to use them as probes of dense objects, including a massive pyramid in Mexico and volcanoes in Japan. American researchers also have proposed using the energetic particles to detect smuggled nuclear materials in vehicles and cargo containers. Muons are formed when cosmic rays from deep space interact with the atmosphere. The particles, which strike earth's surface at the rate of about 10,000 per square meter per minute, pass through large amounts of rock or metal with ease, yet their charge makes them easy to track.

Researchers described several promising uses for muon radiography, as it is called, at the annual meeting of the American Association for the Advancement of Science (AAAS).

Arturo Menchaca-Rocha, director of the physics institute at the National Autonomous University of Mexico leads a team that is deploying muon detectors in a tunnel 26 feet below the base of the Pyramid of the Sun in Teotihuacan, about 30 miles northeast of Mexico City. The researchers hope to find any hidden burial chambers or other interior features of the massive pyramid, which is about 740 feet on each side and 215 feet tall. Linda Manzanilla, an archaeologist, is collaborating in the research effort.

Menchaca-Rocha's team has been doing calibration of its instruments in preparation for taking a year's data on muon flux through the pyramid. The team will be looking for any surplus of muons striking a portion of its detector array compared to the background flux. That would be an indication that voids in the pyramid have allowed more particles to pass through to the detectors than expected. The denser an object, the less likely the muons are to pass through. The detector consists of an array of thin wires immersed in a gas. A muon passing through the detector will create an electric charge in the gas that can be picked up as a localized current in the wires.

Menchaca-Rocha and his colleagues are following in the footsteps of the late Luis Alvarez, a Nobel physics laureate from the University of California, Berkeley. In the late 1960s, Alvarez placed muon detectors in a tunnel beneath the Great Pyramid of Chefren in Egypt in search of hidden burial chambers. None were discovered.

Another speaker at the meeting, Kanetada Nagamine of the KEK Muon Science Laboratory in Japan, reports on his team's use of cosmic-ray muons to essentially take X-rays of the interior of volcanoes for hints of their eruption potential. Nagamine and his colleagues exploit the fact that some high-energy muons are traveling almost horizontally when they reach Earth's surface. By placing multiple muon detectors around a mountain, the scientists can measure its shape and look for interior channels where molten rock may be rising, an early sign of a potential eruption. The research team has studied several volcanoes in Japan, including as assessment of the amount of molten rock within the crater of Mt. Asama.

Closer to home, scientists at Los Alamos National Laboratory in New Mexico have been exploring the use of muon radiography to detect illicit nuclear materials in cargo containers or trucks. Existing X-ray devices, already being deployed at ports and border crossings, cannot readily detect a well-shielded cache of highly enriched uranium, material that could be used in a devastating nuclear bomb. Newer scanning methods, using either dual-beam X-rays or neutrons, can pose radiation hazards to security personnel or illegal immigrants who might stow away in a container.

The muon detection method would involve passive monitoring of vehicles and cargo containers,

with no artificial dose of radiation involved, according to the Los Alamos researchers. Truck drivers could remain in their vehicles while the scan is underway. "We measure the angle of a muon coming in and the angle going out," said Christopher Morris, a member of the Los Alamos team. "The change in angle tells us how much material was in the path."

It takes about 30 to 60 seconds to track enough muons for each cargo container screened, Morris said. There have been questions on whether the method is quick enough to allow prompt screening of large numbers of vehicles or cargo containers. "We've been fighting the general perception that there are not enough muons to measure," Morris said. "There really are." The team is developing better software techniques to allow rapid 3-dimensional images of the volumes being screened. They can reliably detect a small cube of uranium - about 4 inches on a side - within a large metal container full of sheep.

While the Los Alamos research is still in its developmental phase, Morris said he is confident a muon detectors, probably at an initial cost of about $1 million each, could make a significant contribution to efforts to tighten screening of vehicles and cargo containers entering the United States.

This AAAS session was organized by Rick Chartrand of the Los Alamos National Laboratory.